Supporting information

Experimental details pertaining the construction of the Supercapacitive Swing Adsorption Module

1. Electrode fabrication: The electrodes were fabricated the following way: 0.083 g 60% Polytetrafluoroethylene (PTFE) dispersion (Sigma-Aldrich) was dispersed in 10 mL ethanol and stirred. PTFE/gluten mixtures were used as the binder. After the PTFE was completely dissolved, 0.8 g BPL carbon, 0.1 g gluten (Hodgson Mill, food grade), and 0.05 g conductive carbon black (Cabot Corporation) was added to the solution. PTFE was chosen because of its excellent film-forming abilities. The gluten served as a co-binder which ensured the sufficient hydrophilicity of the binder mixture. Carbon black was added to increase the conductivity of the electrodes. The final ratio of BPL:Carbon black:Gluten:PTFE was 80:5:10:5 by mass. The solution was then stirred at 60°C in a vial for 2 hours. Afterwards, the ethanol was evaporated at 80°C until the mixture became a slurry. The slurry was then transferred to a flat glass panel and mixed thoroughly with a metal spatula for 1 hour until the slurry became a sticky dough-like substance. Then, the dough was rolled against a glass slide using a glass vial having a diameter of 2.54 cm to form a sheet with uniform thickness. Subsequently, two 1.4 cm x 1.4 cm sheets were cut out and used as electrodes. The mass of the electrodes was adjusted by modifying the thickness of the sheet. The electrodes were dried at 100°C for 12 hours in a vacuum oven to remove any solvent residue (the pressure in the oven was ~25 mmHg).

Assembly of the Module: Two square aluminum plates with 3 cm x 3 cm size served as mechanical support and current collector for the device. The thickness for the top and bottom aluminum plates were 1/2 inch and 1/4 inch, respectively. Two holes (1 mm diameter), which served as gas inlet and outlet ports, were drilled into the top aluminum plate. These holes were connected to 1/8'' diameter stainless steel tubing via Swagelok connectors. In addition, each aluminum plate had eight additional holes near the edges which would fit eight set screws that would hold the entire module together. Both aluminum plates had a 2 cm x 2 cm x 1 mm recess area in the center. Two square (2 x 2 cm) graphite plates with a thickness of ¼ inch (grey) were fitted into the recess of the aluminum plates. The top graphite plate contained two holes (1 mm diameter) that aligned with the holes in the top aluminum plate. The top graphite plate had 1 mm wide and

1mm deep serpentine gas flow channels, leading from the first hole in the graphite plate to the second hole in the graphite plate (**Figure S2**). Graphite was chosen as material because it does not corrode when in contact with aqueous electrolytes, and provides good electronic conductivity. We chose to implement gas flow channels into only one of the two graphite plates in order to achieve the same electrode configuration (only one electrode is gas-exposed), as in our previous experiments with the block-shaped carbon electrodes (**Figure S1**).

One of the previously prepared electrodes was soaked completely in 1 M NaCl for 2 hours, and used as the anode. The other electrode was wetted with electrolyte solution on only one side, so that the other side remained accessible for gas molecules. After that, a separator membrane (1.6 cm x 1.6 cm) was cut from a Whatman Grade 2 filter paper (GE Healthcare Life Sciences) and placed in between the electrodes to prevent short-circuiting between them. The sandwich made of the two electrodes and the separating membrane was transferred onto the bottom graphite plate, so that the fully electrolyte-soaked bottom electrode was in contact with this graphite plate. A 2 cm x 2 cm rubber seal (gasket) with an 1.7 cm x 1.7 cm opening was cut from an EPDM rubber sheet (1/8 in, McMaster-Carr) and placed on top of the electrode sandwich. A high-vacuum grease (Apiezon M grease) was applied to the rubber seal to prevent leaking. Then a 1.4 cm x 1.4 cm sized carbon cloth (AvCarb 1071 HCB) was placed on the top electrode. The cloth acted as gas diffusion layer that would provide gas access to the entire electrode area. The top aluminum plate and bottom aluminum plate was then clamped together by 8 electrically insulating set screws. These screws were tightened evenly to 15 Nm using a torque wrench. A complete materials sheet for the device is shown in **Table S1** and the entire assembly is shown in **Figure S3.**

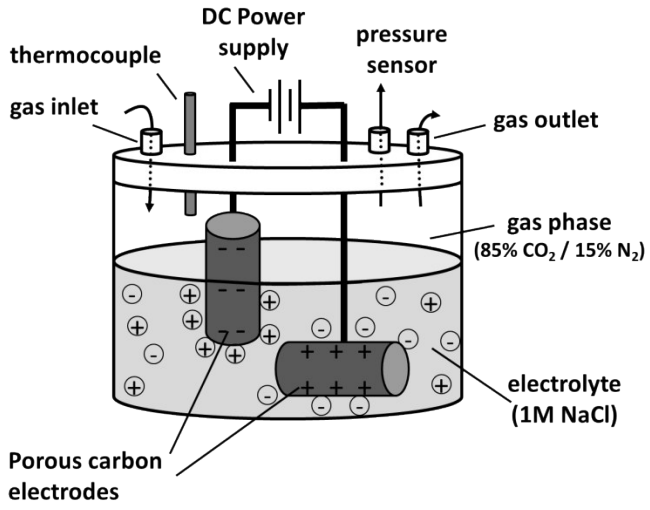

Figure S1. Gas adsorption cell for the demonstration of the supercapacitive swing adsorption effect.

Figure S2: Aluminum current collector and graphite plate with gas flow channels.

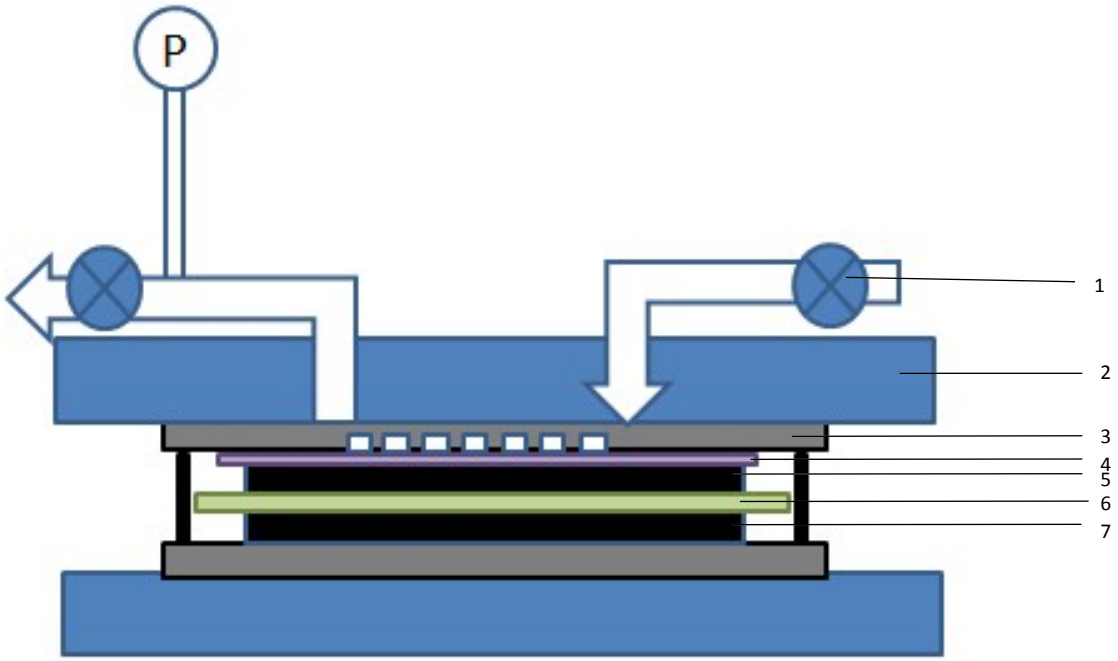

Fig. S3 A SSA gas separation module, cross-sectional view. 1. Valve, 2. Aluminum block. 3. Graphite plate with gas diffusion channels. 4. Carbon cloth. 5. Top electrode. 6. Separator. 7. Bottom electrode.

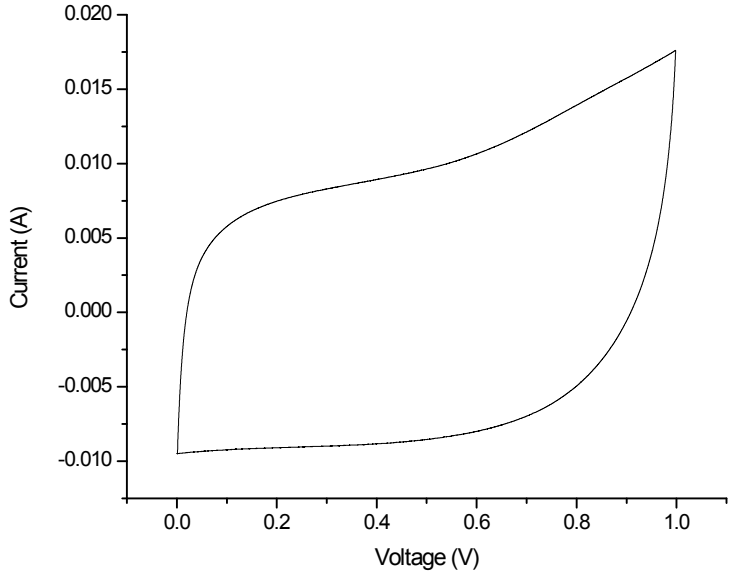

Figure S4. CV curve of the SSA module (scanning rate: 1 mV/second).

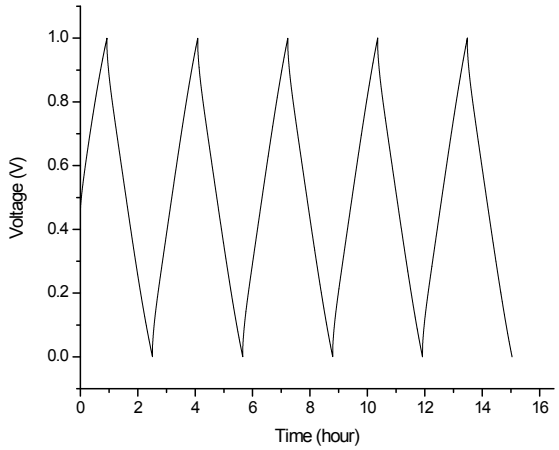

Figure S5. Galvanostatic charge-discharge experiments with an SSA module (current = 1 mA).

Table S1: Materials sheet of a Supercapacitive Swing Adsorption Module.

Component	Vendor	Size/Model No.
Pressure transducer	Omega	MMA015C1T3C2TA5S
Dielectric connection	Swagelok	SS-6-DE-6
Stainless steel tube	Swagelok	SS-T2-S-028-20, 1/8 in
Graphite plate	McMaster-Carr	1/4 in
Aluminum plate	McMaster-carr	1/2 in, 1/4 in
Separator membrane	Whatman	Filter paper grade 2
Rubber sealer	McMaster-Carr	High-Strength 60A EPDM rubber, 1/8 in
High vacuum grease	Apiezon	
Carbon cloth	Avcarb	1071 HCB, 20 cm * 20 cm